

What is claimed is:

1. A method for constructing a composite response surface based on neural networks and selected functions, the method comprising:

- (1) providing a set of  $h$  initial parameters that determine variation of provided data for a target variable, where each parameter corresponds to a coordinate in an  $h$ -dimensional parameter space  $G$ ;
- (2) providing a decomposition of the  $h$  parameters into a first set of  $s$  simple parameters  $f_i$ , numbered  $i = 1, \dots, s$ , that may be used to describe the provided data with polynomials of total degree no greater than a selected number  $M_s$ , and a second set of  $c$  complex parameters  $g_j$ , numbered  $j = 1, \dots, c$ , that may be used to describe the provided data using neural networks, and with  $s + c = h$ , where  $s, c$  and  $M_s$  are selected positive integers;
- (3) providing a simplex, having  $s+1$  vertices, numbered  $k = 1, \dots, s+1$ , and centered at a selected point in the space  $G$ ;
- (4) applying a neural network for each of the  $s+1$  vertices, and training each of the  $s+1$  neural networks, using selected simulation data obtained by varying the parameters  $g_j$  to generate a first sequence of network functions  $R_k(g_1, \dots, g_c)$ ;
- (5) providing a second sequence of shape functions  $P_k(f_1, \dots, f_s)$  that satisfy the conditions  $P_k(f_1, \dots, f_s) = 1$  at the vertex numbered  $k$  and  $P_k(f_1, \dots, f_s) = 0$  at any vertex other than vertex number  $k$ , and  $\sum P_k(f_1, \dots, f_s) = 1$  for all values of  $f_1, \dots, f_s$ ; and
- (6) forming a composite function  $CRS(f_i, g_j)$  defined by

$s+1$

$$CRS\{f_i, g_j\} = \sum_{k=1}^{s+1} P_k(f_1, \dots, f_s) R_k(g_1, \dots, g_c).$$

2. The method of claim 1, further comprising selecting said set of complex parameters to include at least one polynomial in said complex parameters  $g_j$  having a selected degree  $M_c$  satisfying  $M_c > M_s$ .

3. The method of claim 1, further comprising choosing said integer  $M_s$  from the group of integers consisting of 1, 2 and 3.

4. The method of claim 1, further comprising selecting said set of complex parameters to include any of said  $h$  parameters that does not qualify as a simple parameter.

5. The method of claim 1, further comprising:

(7) providing an objective function  $OBJ(f_k, g_j)_n$ , dependent upon at least one of the parameter values  $f_1, \dots, f_s, g_1, \dots, g_e$ , for the composite function  $CRS\{f_k, g_j\}$  at each of  $N$  selected locations in  $G$  space, numbered  $n = 1, \dots, N$ , associated with the target variable, and providing a corresponding objective function value  $OBJ_n$  for the target variable at each of the  $N$  selected locations, where  $n$  is a selected positive integer;

(8) computing a training error value  $TE\{g_j\}$  as a non-negative weighted sum of functions of differences  $F_n(OBJ_n - OBJ(f_k, g_j)_n)$ , where each function  $F_n$  is monotonically increasing in a magnitude of the function argument and has a value 0 where the function argument is 0;

(9) when the training error value  $TE\{g_j\}$  is greater than a selected threshold error value  $\epsilon$ , providing at least one of a modified set of shape functions  $P_k(f_1, \dots, f_s)$ , and returning to step (6); and

(10) when the training error  $TE\{g_j\}$  is no greater than the threshold error value  $\epsilon$ , accepting the present composite response surface.

6. The method of claim 1, further comprising applying said composite response surface to optimization of a design of a physical object.

7. The method of claim 6, further comprising choosing said physical object to be a shape for an aircraft component.

8. The method of claim 1, further comprising applying said composite response surface to modeling of a response to a process.

9. The method of claim 1, further comprising applying said composite response surface to modeling response of a physical object.